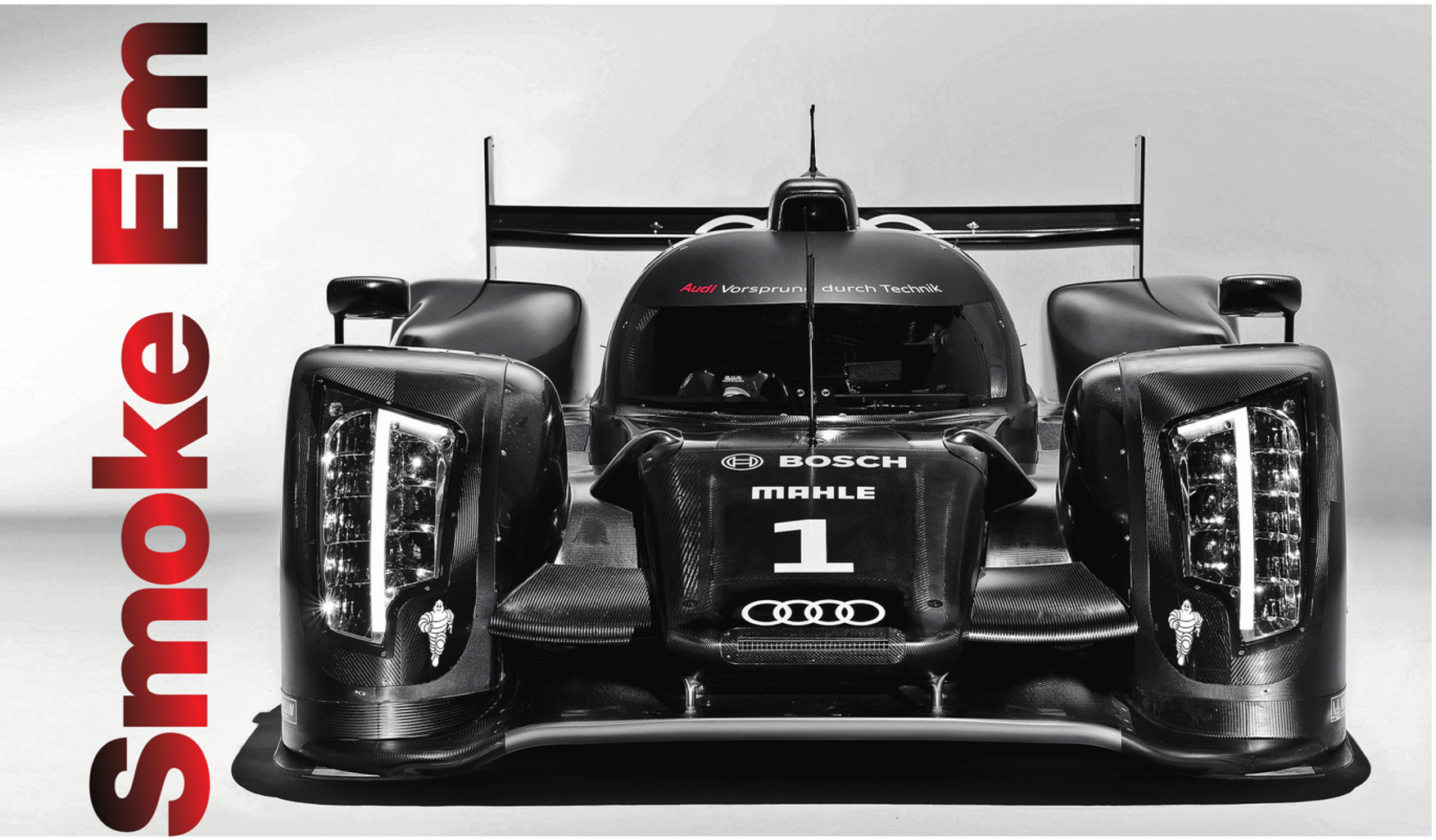
## AN IDIOT'S GUIDE TO DIESEL TUNING...

# Smoke Em







Regular readers will be all too aware of just how blown away we've been with our seemingly indestructible tuned Mk5 Golf TDI [aka Project Slow]. So much so that we decided to speak to tuning guru, David Bywater, of diesel specialist, Haslemere Tuning, to discover exactly what makes a good oil burner tick.

### A BRIEF HISTORY

Diesel tuning has been the big new thing in the last decade, but unless you've actually tried it, chances are it's passed you by. The traditional view of diesel engines is that they are slow, heavy, labouring things that only belong in lorries, buses and taxis; but now there are GTIs with them in!

Many will be familiar with traditional rotary diesel pumps. There were ECU versions of these, such as the Bosch VP44, but these were in a relatively few vehicles. They only really suited larger capacity engines, and they were not quite as accurate as what followed.

The real revolution in car diesel engine technology came in the late 1990s. Alfa Romeo is credited with being the first to introduce common rail (CR) fuel injection in its 156 1.9JTD. CR had actually been around for a while in various guises, but hadn't made it into cars before. It brought full ECU control into ordinary diesel engines, and opened up a whole new raft of tuning opportunity.

A CR diesel engine has a high-pressure fuel pump on the engine which generates up to 1800bar (26,460psi) of pressure. This feeds a single (common) fuel rail to which the injectors are connected, rather than each injector having its own feed (as on a conventional diesel pump). The injectors are controlled by an ECU in much the same way as a petrol engine – various sensors take measurements from the engine, the appropriate amount of fuel is calculated, and the injectors are opened accordingly. All CR engines inject fuel directly into the combustion chamber, so there is a relatively small time-frame in each engine cycle during which fuel has to be injected. Even then, the fuel may be delivered in several small bursts to keep exhaust emissions and noise down.

VAG took a slightly different path. It developed the Pumpe Düse (PD) system, which is similar to CR. The big difference is that much of the pressure required to force the diesel through the injector is generated by a cam working on the top of the injector. This allows a lower rail pressure, but puts a further mechanical restriction on when the fuel could be injected. Its latest generation engines now use CR, and using modern piezo injectors can deliver really accurate fuelling.

### INTERCOOLING

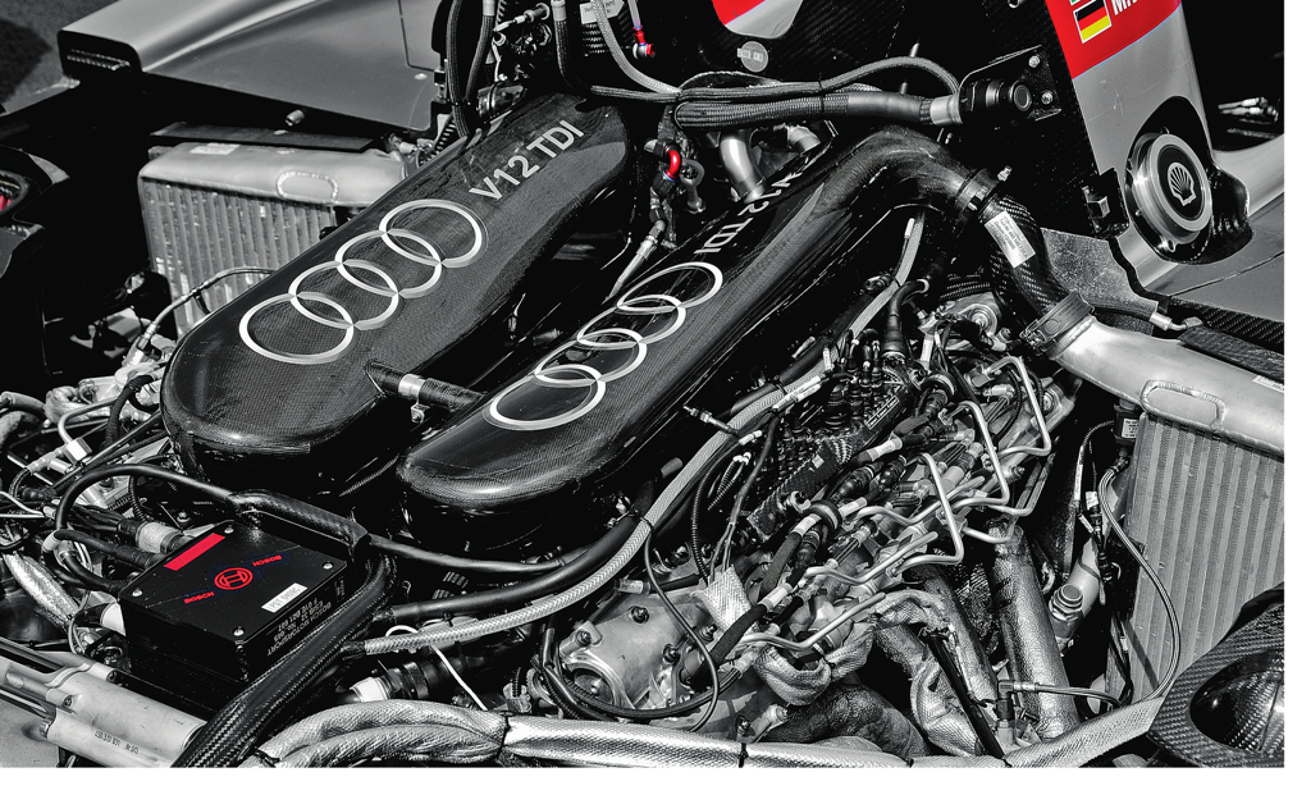
Turbos compress air to allow more oxygen to be packed into the combustion chamber. When you compress a gas it warms up, so most forced induction engines have an intercooler. This is an air-to-air heat exchanger that looks like a radiator with rather large hoses. If you intend to make your diesel engine make more power, you are likely to be raising the boost level. This puts more heat into the air and more physical pressure on the inside of the intercooler.

Before upgrading your engine, it's worth having a look underneath the intercooler. Most VAG diesels use an intercooler with ends pressed on, and over time they begin to leak. Look for drips of oil coming from the seams – it may be worth changing the intercooler before you make it work harder. Re-check after you've run the upgrade for a couple of weeks, just in case.

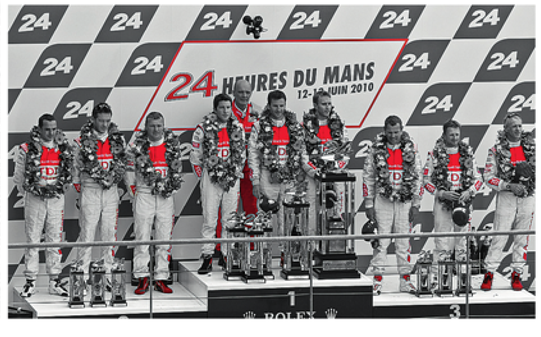
If you have to change an elderly intercooler anyway, you might consider upgrading it. A more efficient or larger unit will allow you to cool more air more effectively, which increases the density of the air entering the engine. This allows you to burn even more fuel. More fuel equals more power, but it's not all gain – there's always a trade-off. A larger intercooler holds more air. This requires more compressing, which takes a bit more time. This adds to turbo lag, so you may find that although you have more ultimate power, it takes noticeably longer to kick in. It's why a PD130 engine often has a livelier tune than the corresponding PD150 – the larger intercooler in the PD150 doesn't lend itself to such a quick response.

Because diesels don't have a specific fuel/air ratio to maintain, you can change an intercooler for a higher specification item with no other modifications. This means that if you are working to a limited budget, you can go step-by-step without having to pay for a new custom remap each time. The worst you might experience is a bit more soot while the turbo is coming up to speed.

Of course, there are other things you can







Any tuning that increases the output of an engine has the potential to shorten its life

## Diesel feature cars in *PVW* (11/08)

### TANK PATEL

Few people know that at the heart of Tank's all-conquering show car lies a nicely tuned 1.9 PD 150. Thanks to a hybrid VT2 turbo, an array of Allard goodies, a 3" Milltek Sport system and a trusty Helix clutch, his car puts down upwards of 235bhp and near 400lb ft of torque.


do to improve intercooling, although they are relatively unusual in the world of diesel tuning. There's nothing to stop you from using water/meth or even nitrous oxide as an intercooling agent! These can be managed by a suitable tuning box, where a 'chipped' ECU would need a supplemental controller.

### AMAL VALVES

The proper name for this is a 'charge pressure control bypass valve', and it is used by the ECU to control the boost pressure. VAG call it an N75 valve, using vacuum control. Most modern turbos have amal valve control, including all later VAG cars.

By controlling the diversion function of this valve, the ECU can control the boost pressure. This is done by setting the valve to bleed off more or less of the pressure, rather than letting it open the wastegate. Tuning can change this profile, and use the amal valve system to adjust the boost pressure. How this is done will depend on the specific application.

### DIESEL PARTICULATE FILTERS

As vehicle manufactures have tried to clean up engine emissions, they have presented diesel tuners with a range of problems. One of the bigger issues has been diesel particulate filters (DPFs). These sit in the exhaust pipe to catch the soot particles that are badly burnt diesel. This is to deal with the black smoke that even standard cars emit when pulling away from stationary – a big problem in towns and cities.

The filters are cleaned by a mode that the engine management enters when the car is cruising at light throttle, such as on a drive down the motorway. If you never give your car a chance to clean the filter, you may find that a warning light appears on the instrument panel to report a partial blockage, and you need to go for a leisurely drive. Half an hour at 60-70mph on light throttle should do the trick.

However, many performance tunes tend towards the smoky, and if the vehicle is driven too enthusiastically for too long, the filter clogs up. You can actually feel the drop in power as the exhaust back-pressure builds up. There are several ways to work around this problem, although some tuners simply decline to work on these vehicles. If performance tuning is your thing, the easiest thing at the moment is to buy a car without a DPF.

### BASIC DIESEL TUNING TECHNIQUES

As with any performance tuning, to generate significantly more power, you have to burn more fuel. To burn that fuel, you need more oxygen, and one of the advantages of diesel engines is that most of them come with both a turbocharger and an intercooler as standard. To add more air, simply turn up the turbo… then you can worry about how to add more fuel!

Of course, these are diesel engines that we are talking about. It's perfectly simple to tune a VW Golf PD130 to give 180bhp and 300lb ft of torque, but still drive it to return 60mpg. In spite of what we might hear in the pub, most of us don't have a chance to max out our performance car on every drive, so although economy might not be the first thing that springs to mind, it's not a bad thing to have! Standard vehicles are tuned to Euro emissions requirements, and this is why cars generally seem a bit flat – all the sparkle has been tuned out of them.

Vehicle manufacturers want their cars to last (at least until the warranty expires!), to work in thin air at high altitudes, and to perform adequately on lower grade fuels. As a result, turbo diesel engines are generally tuned with a bit of margin. Obviously the first thing we can do is to take up the slack that is this margin. Some drivers use the altered mapping to drive more efficiently, but most people who want more power from their engine will generally use it!

There's more than one way to remap an engine – most people call it 'chipping', but this only really refers to reprogramming one of the silicon chips in the ECU with new parameters. The other main method of remapping a diesel engine involves connecting piggy-back electronic components, which may be as sophisticated as an extra ECU. These units can allow information from the sensors to be manipulated, timing to be adjusted, and valves and injectors on the engine to be controlled when the OEM ECU wasn't planning to.

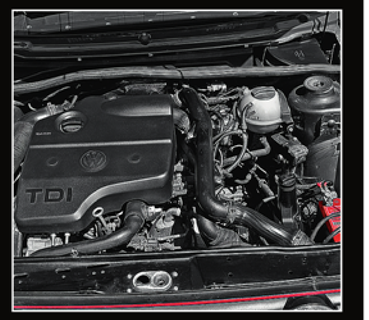
Chipping is well established and there are many companies offering it. Some even offer a free trial so you can test the conversion before you actually hand over your hard-earned cash. It's quick and easy to install, but you generally have to take the car to a specialist, and the upgrade stays with the vehicle – you can't take it off when you sell the car on. Many of the tunes are very similar to the OEM map, just with a general lift in power and torque across the map.

Piggy-back ECUs (also known as tuning boxes) plug into the engine wiring loom. There is normally a vehicle-specific adaptor to plug the tuning box into the car, and they can be unplugged just as easily. This means they can be bought by mail order and installed by any adept DIY mechanic. There is a wide range out there, although some of them are not all that you would want them to be. Unfortunately, some can be as basic as a device to plug across the engine coolant temperature sensor (which will generally put an engine management light on), and are worth avoiding. So, how do you choose a good one?

When choosing any performance upgrade, it's hard to beat a personal

## Diesel feature cars in *PVW* (12/06)

### KEVIN MacDOUGALL



Kev's Mk2 TDI wasn't just built to go but he was after a super-efficient Dub to drive when he wasn't running his petrol Mk2 show car. The solution was this Nimbus grey 1.9 TDI car running an 02A gearbox, hydraulic clutch with cable change, drive-by-wire pedal setup, A3 TDI intercooler and the pièce de résistance, a 17-gallon tank mounted in a false floor to hold the waste oil which feeds the DIY grease conversion. Yes, it's powered by chip fat!

## When choosing any performance upgrade, it's hard to beat a personal recommendation

recommendation. If you don't know anybody to ask, is there a tuning company whose advice you trust? After that, it's a bit more difficult. One clue can be in the connectors that link the tuning box into the OEM vehicle. The more pins in the connectors, the more circuits that it might be working with, and the better job it can do. Some tuning boxes have a driver control so the upgrade can be turned down when it is not required. This is very useful on an older engine at MoT time, or if you don't want your partner to know just how much fun the car is! The really good tuning boxes even allow the upgrade to be tweaked to suit the car and the driver during the road test. You are going to have to take the car to the specialist for this level of installation, but it's the only way to have the upgrade that suits you best. Essentially, once the tuning box has been installed, the map can be adjusted by laptop while the car is being driven. That's what we installed on Lee's Mk4 Golf PD130 and Elliott's B7 Audi A4 PD140. The diesel tuning box supplied by VAG specialist, The Phirm, can be set up to work with either of these engines, even though the PD130 uses EDC15 management, and the PD140 uses EDC16.

It's a neat trick if you can do it but there's always a down-side; any tuning that increases the output of an engine has the potential to shorten its life – although this doesn't have to be by a significant amount. As long as the original vehicle is maintained to a reasonable standard and any minor problems are dealt with properly, an upgraded diesel engine can last just as long as a standard one. We've even developed tuning boxes that were approved by the vehicle manufacturer, and sold through their dealer network.

You have to consider the rest of the car as well. Improving the performance of the engine provides an opportunity for the driver to work the cooling system, transmission, brakes, tyres and suspension much harder. So it's important to make sure that the car can cope with the power. However, there are some things that a tuner might do which will cause long term problems, and unless you know a lot about the way the upgrade works, you have no way to work out whether you might expect to experience them.

There are two areas that typically cause problems, the first being the turbo. To make more pressure, it has to both work harder and spin faster. If you take this too far for too long, the turbo is going to have a spectacular but expensive end.

The other doesn't apply to the PD engines, but does to the most recent CR vehicles, and that is fuel rail pressure tuning. It's possible to add more fuel by increasing the rail pressure, which means that more fuel is injected for a given injector period. Part of the problem is that the rail has a safety valve to prevent the system from reaching a dangerous pressure if something goes wrong. Too much increase in this pressure (especially at high RPM, high load combinations) will cause this relief valve to be tripped. This will normally happen when you come off the power and the injectors shut for over-run. The other main issue is that it can make the fuel system prone to developing leaks. Although there is a place for rail pressure adjustment, it shouldn't be used for big power increases.

### TUNING A DIESEL ENGINE

The first thing you should always do before remapping any engine is to make sure that it's in reasonable condition. If you start putting big power through that 150k mile turbo, it really isn't going to last for very long. It's also worth putting a scan tool on the car to make sure there are no hidden fault codes. We didn't find any problems with Lee's Golf, but there was a broken sensor on Elliott's Audi that needed replacing. Read more about both upgrades in a future instalment of *Our Cars*.

So how do you remap a diesel engine? It's not something that most people are ever going to need to do, because the basic maps will be perfectly good for most applications. However, what if a chip tune or tuning box is part of a bigger package? Road mapping is a useful technique if you've just put a big turbo and barn-door-sized intercooler into the car, and that's when you really want the finest tuning control to make the most of the car.

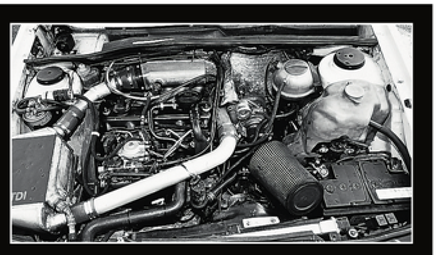
The first thing to remember is that diesel engines don't have a throttle body in the same way as petrol engines. You don't have to maintain a fuel/air mixture to prevent the engine from self-destructing: all you need to do is make sure that there is at least enough air to burn the diesel that you are injecting. If you don't have enough air, unburnt diesel comes out of the exhaust pipe as black smoke, which is why even standard cars can blow a bit of soot while the turbo is beginning to spin.

Sometimes it's easier to start with the boost map, especially if you are targeting a big power increase. The turbo is under closed-loop control, so if you ask for more than it can deliver at some point in the map, the ECU will eventually flag up an under-boost error. When you know how much air will be available, it's easier to tell that you've reached the fuel limit when you're working on that map. Once the fuel map is complete, you can reduce the boost where it isn't needed to give the turbo an easier life.

For most diesel vehicles, there is no point in remapping the fuel timing. Adjusting the timing might give a power increase and could reduce the exhaust gas temperatures. In practice, on many European and Japanese diesel engines the timing has been optimised either by a good factory tune, or even by a knock sensor. As a result, many upgrade tunes don't adjust fuel timing – most tuning boxes don't even have facility to do this.

So, now all you need to do is work out how much fuel you want to add. Do you want an aggressive sports tune that allows you to rip through the bottom of the rev range? Are you after a touring setup that gives a good punchy mid-range? Or do you need something suitable for your race car? The choice is yours ●

## Diesel feature cars in *PVW* (6/010)



### SIMON COOPER

Simon is something of a diesel-tuning guru. When we featured his infamous Mk2 TDI back in 2001 at one of our group thrashes, not only did the car produce a sub 7-second sprint to 60mph, but it finished in forth position on the day, out of a total of eleven cars. Back then the car was only running conservative (less than 2bar) boost, but the 90bhp-base engine certainly got the job done thanks to its 360° turbo, hybrid fuel pump, charge-cooler, worked on head, one-off Piper cam, race-spec injectors and a four-branch manifold. Amazing!

### CONTACT:

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